

WHAT IS CLAIMED IS:

1. A method for controlling speed in a pulse-width-modulation-controlled motor powered by a load voltage source, said method comprising the steps of:

measuring the motor load voltage; and

setting a pulse-width-modulation duty cycle based on the measured voltage.

2. A method in accordance with Claim 1 wherein said steps are sequentially executed and repeated automatically while the motor is in an on state.

3. A method in accordance with Claim 1 wherein a supply voltage supplies the load voltage, said method further comprising the step of diagnosing a motor functionality using a difference between the supply voltage and the load voltage.

4. A method in accordance with Claim 1 wherein said step of measuring the motor load voltage further comprises utilizing at least one switching element to bypass a resistive element.

5. A method in accordance with Claim 3 wherein the supply voltage is unregulated.

6. A method in accordance with Claim 3 wherein the supply voltage is direct current.

7. A method for controlling speed in a pulse-width-modulation-controlled motor powered by a load voltage, the load voltage supplied by a supply voltage, said method comprising the steps of:

diagnosing motor functionality using a difference between the supply voltage and the load voltage; and

switching from motor functionality diagnosis to motor speed control.

8. A method in accordance with Claim 7 wherein said step of diagnosing motor functionality comprises the step of using a pulse width modulation duty cycle of 100 percent.

9. A method in accordance with Claim 7 wherein said step of diagnosing motor functionality using a difference between the supply voltage and the load voltage comprises calculating power used by the motor in accordance with:

$$\frac{[(Upper\_A/D\_Reading) - (Lower\_A/D\_Reading)]^2}{R_{sense}}$$

where *Upper\_A/D\_Reading* is the supply voltage measurement, *Lower\_A/D\_Reading* is the load voltage measurement, and *R<sub>sense</sub>* is a resistance between measurement locations for *Upper\_A/D\_Reading* and *Lower\_A/D\_Reading*.

10. A closed loop motor control system, said system comprising:

a motor;

a power source;

a resistive element electrically coupling said motor to said power source;

at least one switching element electrically coupling said motor to said power source in parallel to said resistive element; and

a processor electrically connected to said switching element, said processor configured to:

determine a load voltage; and

set a pulse width modulation duty cycle based on the determined voltage.

11. A closed loop system in accordance with Claim 10 wherein said processor further configured to:

determine the load voltage while the motor is in an on state repeatedly automatically; and

set a pulse width modulation duty cycle based on the determined voltage while the motor is in an on state repeatedly automatically.

12. A closed loop system in accordance with Claim 10 wherein said processor further configured to diagnose motor functionality.

13. A closed loop system in accordance with Claim 12 wherein said processor further configured to diagnose motor functionality using a pulse width modulation duty cycle of 100 percent.

14. A closed loop system in accordance with Claim 12 wherein said processor further configured to diagnose motor functionality by calculating power used by the motor in accordance with:

$$\frac{[(Upper\_A/D\_Reading) - (Lower\_A/D\_Reading)]^2}{R_{sense}}$$

where *Upper\_A/D\_Reading* is a supply voltage measurement, *Lower\_A/D\_Reading* is a load voltage measurement, and *R<sub>sense</sub>* is a resistance between measurement locations for *Upper\_A/D\_Reading* and *Lower\_A/D\_Reading*.

15. A system in accordance with Claim 10 wherein said power source comprises an unregulated voltage supply.

16. A system in accordance with Claim 15 wherein said unregulated voltage supply comprises an unregulated DC voltage supply.

17. A method for operating a motor configured to operate at a variable average speed under pulse-width modulation control, said method comprising the steps of:

energizing the motor; and

setting an average speed by superimposing a sweep frequency onto an average pulse-width modulation frequency.

<sup>18</sup> A method in accordance with Claim 18 wherein said step of setting an average speed further comprises the step of setting an average speed by superimposing a sweep frequency range onto an average pulse-width modulation frequency forming a monotonically increasing waveform.

<sup>19</sup>  
~~20~~ A method in accordance with Claim 18 wherein said step of setting an average speed further comprises the step of setting an average speed by superimposing a sweep frequency range onto an average pulse-width modulation frequency forming a monotonically decreasing waveform.

<sup>20</sup>  
21. A method in accordance with Claim 18 wherein said step of setting an average speed further comprises the step of setting an average speed by superimposing a sweep frequency range onto an average pulse-width modulation frequency forming a random waveform centered around the average pulse-width modulation frequency.

<sup>21</sup>  
22. A method in accordance with Claim 18 wherein said step of setting an average speed further comprises the step of setting an average speed by superimposing a sweep frequency range onto an average pulse-width modulation frequency forming a monotonically increasing waveform with a low value approximately 20% below the average and a high value approximately 20% above the average.

<sup>22</sup>  
23. A method in accordance with Claim 18 wherein said step of setting an average speed further comprises the step of setting an average speed by superimposing a sweep frequency range onto an average pulse-width modulation frequency forming a monotonically decreasing waveform with a low value approximately 20% below the average and a high value approximately 20% above the average.

<sup>23</sup>  
24. A method in accordance with Claim 18 wherein said step of setting an average speed further comprises the step of setting an average speed by superimposing a sweep frequency range onto an average pulse-width modulation frequency forming a random waveform centered around the average pulse-width modulation frequency with a low value approximately 20% below the average and a high value approximately 20% above the average.

<sup>24</sup>  
25. A method in accordance with Claim 18 wherein said step of setting an average speed further comprises the step of setting an average speed by superimposing a sweep frequency range onto an average pulse-width modulation frequency forming a monotonically increasing waveform with a low value at least approximately 5% below the average and a high value at least approximately 5% above the average.

<sup>25</sup>  
26. A method in accordance with Claim 18 wherein said step of setting an average speed further comprises the step of setting an average speed by superimposing a sweep frequency range onto an average pulse-width modulation frequency forming a monotonically decreasing waveform with a low value at least approximately 5% below the average and a high value at least approximately 5% above the average.

<sup>26</sup>  
27. A method in accordance with Claim 18 wherein said step of setting an average speed further comprises the step of setting an average speed by superimposing a sweep frequency range onto an average pulse-width modulation frequency forming a random waveform centered around the average pulse-width modulation frequency with a low value at least approximately 5% below the average and a high value at least approximately 5% above the average.

<sup>27</sup>  
28. A motor comprising:

a housing;

a stator mounted in said housing, said stator comprising a stator bore;

a rotor rotatably mounted at least partially within said stator bore; and

a processor electrically connected to at least one of said stator and said rotor, said processor configured to:

determine a load voltage; and

set a pulse width modulation duty cycle based on the determined voltage.

<sup>28</sup>  
29. A motor in accordance with Claim 28 wherein said processor further configured to diagnose motor functionality.

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30. A motor in accordance with Claim 29 wherein said processor further configured to diagnose motor functionality by calculating power use in accordance with:

$$\frac{[(Upper\_A/D\_Reading) - (Lower\_A/D\_Reading)]^2}{R_{sense}}$$

where *Upper\_A/D\_Reading* is a supply voltage measurement, *Lower\_A/D\_Reading* is a load voltage measurement, and *R<sub>sense</sub>* is a resistance between measurement locations for *Upper\_A/D\_Reading* and *Lower\_A/D\_Reading*.

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31. A motor comprising:

a housing;

a stator mounted in said housing, said stator comprising a stator bore;

a rotor rotatably mounted at least partially within said stator bore; and

a processor electrically connected to at least one of said stator and said rotor, said processor configured to set an average speed by superimposing a sweep frequency onto an average pulse-width modulation frequency.

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32. A motor in accordance with Claim 31 wherein said processor further configured to set an average speed by superimposing a sweep frequency range onto an average pulse-width modulation frequency forming a monotonically increasing waveform.

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33. A motor in accordance with Claim 31 wherein said processor further configured to set an average speed by superimposing a sweep frequency range onto an average pulse-width modulation frequency forming a monotonically decreasing waveform.

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34. A motor in accordance with Claim 31 wherein said processor further configured to set an average speed by superimposing a sweep frequency range onto an average pulse-width modulation frequency forming a random waveform centered around the average pulse-width modulation frequency.

<sup>34</sup>  
35. A motor in accordance with Claim 31 wherein said processor further configured to set an average speed by superimposing a sweep frequency range onto an average pulse-width modulation frequency forming a monotonically increasing waveform with a low value approximately 20% below the average and a high value approximately 20% above the average.

<sup>35</sup>  
36. A motor in accordance with Claim 31 wherein said processor further configured to set an average speed by superimposing a sweep frequency range onto an average pulse-width modulation frequency forming a monotonically decreasing waveform with a low value approximately 20% below the average and a high value approximately 20% above the average.

<sup>36</sup>  
37. A motor in accordance with Claim 31 wherein said processor further configured to set an average speed by superimposing a sweep frequency range onto an average pulse-width modulation frequency forming a random waveform centered around the average pulse-width modulation frequency with a low value approximately 20% below the average and a high value approximately 20% above the average.

<sup>37</sup>  
38. A motor in accordance with Claim 31 wherein said processor further configured to set an average speed by superimposing a sweep frequency range onto an average pulse-width modulation frequency forming a monotonically increasing waveform with a low value at least approximately 5% below the average and a high value at least approximately 5% above the average.

<sup>38</sup>  
39. A motor in accordance with Claim 31 wherein said processor further configured to set an average speed by superimposing a sweep frequency range onto an average pulse-width modulation frequency forming a monotonically decreasing waveform with a low value at least approximately 5% below the average and a high value at least approximately 5% above the average.

<sup>39</sup>  
40. A motor in accordance with Claim 31 wherein said processor further configured to set an average speed by superimposing a sweep frequency range onto an average pulse-width modulation frequency forming a random waveform centered around the average pulse-width modulation frequency with a low value at least approximately 5% below the average and a high value at least approximately 5% above the average.

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41. A refrigerator comprising:

a housing;

a freezer section at least partially within said housing;

a fresh food section at least partially within said housing;

a motor at least partially within said housing; and

a processor electrically connected to said motor, said processor configured to set an average speed by superimposing a sweep frequency onto an average pulse-width modulation frequency.

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42. A refrigerator in accordance with Claim 41 wherein said processor further configured to set an average speed by superimposing a sweep frequency range onto an average pulse-width modulation frequency forming a monotonically increasing waveform.

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43. A refrigerator in accordance with Claim 41 wherein said processor further configured to set an average speed by superimposing a sweep frequency range onto an average pulse-width modulation frequency forming a monotonically decreasing waveform.

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44. A refrigerator in accordance with Claim 41 wherein said processor further configured to set an average speed by superimposing a sweep frequency range onto an average pulse-width modulation frequency forming a random waveform centered around the average pulse-width modulation frequency.

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45. A refrigerator in accordance with Claim 41 wherein said processor further configured to set an average speed by superimposing a sweep frequency range onto an average pulse-width modulation frequency forming a monotonically increasing waveform with a low value approximately 20% below the average and a high value approximately 20% above the average.

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46. A refrigerator in accordance with Claim 41 wherein said processor further configured to set an average speed by superimposing a sweep frequency range onto an average pulse-width modulation frequency forming a monotonically decreasing waveform with a low value approximately 20% below the average and a high value approximately 20% above the average.



<sup>46</sup>  
47. A refrigerator in accordance with Claim 41 wherein said processor further configured to set an average speed by superimposing a sweep frequency range onto an average pulse-width modulation frequency forming a random waveform centered around the average pulse-width modulation frequency with a low value approximately 20% below the average and a high value approximately 20% above the average.

<sup>47</sup>  
48. A refrigerator in accordance with Claim 41 wherein said processor further configured to set an average speed by superimposing a sweep frequency range onto an average pulse-width modulation frequency forming a monotonically increasing waveform with a low value at least approximately 5% below the average and a high value at least approximately 5% above the average.

<sup>48</sup>  
49. A refrigerator in accordance with Claim 41 wherein said processor further configured to set an average speed by superimposing a sweep frequency range onto an average pulse-width modulation frequency forming a monotonically decreasing waveform with a low value at least approximately 5% below the average and a high value at least approximately 5% above the average.

<sup>49</sup>  
50. A refrigerator in accordance with Claim 41 wherein said processor further configured to set an average speed by superimposing a sweep frequency range onto an average pulse-width modulation frequency forming a random waveform centered around the average pulse-width modulation frequency with a low value at least approximately 5% below the average and a high value at least approximately 5% above the average.

<sup>50</sup>  
51. A refrigerator comprising:

a housing;

a freezer section at least partially within said housing;

a fresh food section at least partially within said housing;

a motor at least partially within said housing; and

a processor electrically connected to said motor, said processor configured to:

determine a load voltage; and

set a pulse width modulation duty cycle based on the determined voltage.

<sup>51</sup>  
52. A refrigerator in accordance with Claim 51 wherein said processor further configured to diagnose motor functionality.

<sup>52</sup>  
53. A motor in accordance with Claim 52 wherein said processor further configured to diagnose motor functionality by calculating power use in accordance with:

$$\frac{[(Upper\_A/D\_Reading) - (Lower\_A/D\_Reading)]^2}{R_{sense}}$$

where  $Upper\_A/D\_Reading$  is a supply voltage measurement,  $Lower\_A/D\_Reading$  is a load voltage measurement, and  $R_{sense}$  is a resistance between measurement locations for  $Upper\_A/D\_Reading$  and  $Lower\_A/D\_Reading$ .